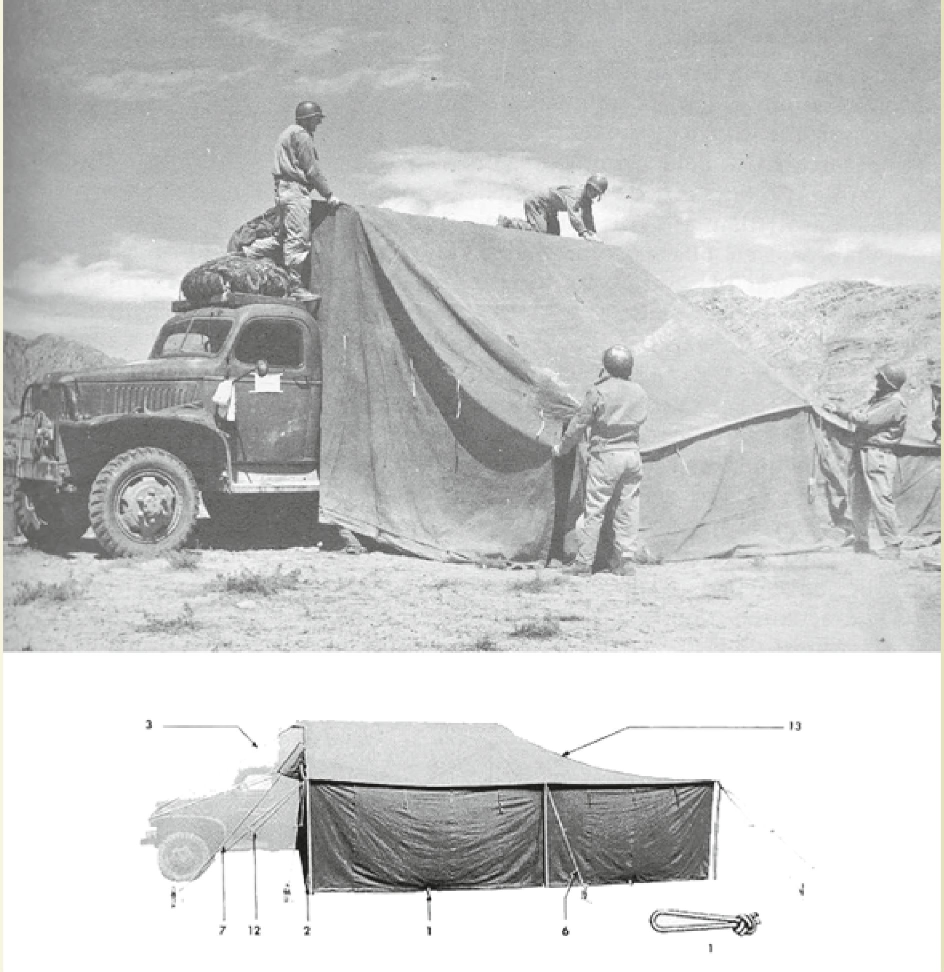
Stephen Verderber



Deploying the tent component over a mobile triage/ surgical truck in Tunisia, North Africa in the Second World War, 1944

These were proven effective as first-response medical aid stations along the front lines in the desert.

Architects as First Responders

Portable Healthcare Architecture in a Climate-Altered World

In both developed and developing countries, medical emergencies caused by the effects of climate change, earthquakes, war or terrorism can wreak havoc with healthcare infrastructure. Where hospitals are lacking, or existing ones are overburdened or put out of action, prefabricated transportable solutions are indispensable for rebuilding afflicted communities. **Stephen Verderber** – a current Professor at the University of Toronto and former Professor in the Graduate Program in Architecture + Health at Clemson University in South Carolina – gives examples of the types of systems that exist, and highlights key considerations to be taken into account by those involved in their design.

Highly challenging global events are upending the rhythms of everyday life. Earthquakes, intense hurricanes and typhoons, flooding, famine, tsunamis, wars and acts of terrorism, ethnic strife, and geopolitical conflicts waged over dwindling natural resources are becoming commonplace. In developed and developing regions alike, tens of millions of people are at increased risk. The Intergovernmental Panel on Climate Change (IPCC) confirms that our planet is experiencing accelerated climate change at a rate significantly faster than previously anticipated.[1] In Bangladesh in 2011 alone, more than 60,000 internally displaced persons (IDPs) became permanently homeless due to rising seas and subsequent widespread inland flooding that overwhelmed the region's already fragile infrastructure.[2] By 2050, it is predicted that nearly 80 per cent of the world's population will reside in coastal zones. This, coupled with the unprecedented ramifications of global climate change, constitutes an ideal recipe for innumerable disasters in the years ahead.[3]

That said, the need exists for the rapid deployment of healthcare infrastructure to medically underserved disaster strike zones: mobile facilities able to be transited, erected and operationalised under very challenging timeframes. In this regard – with more individuals and places than ever susceptible to life-threatening outcomes of wider scope, intensity and duration – the World Health Organization (WHO) is calling for architectural research and development to invent innovative, sustainable, resilient responses to these adverse global events.

Conventional, fixed-site hospitals certainly serve a critical role in such situations, although they themselves are susceptible to fails because they are 'sitting ducks', so to speak.[4] Permanently sited institutions are at risk of shutdown for weeks if not months, as occurred in the aftermath of Hurricane Katrina in New Orleans in 2005.[5] Transportable clinics, alternatively, offer a flexible counterpoint to conventional brick-and-mortar hospitals and clinics: they are able to be expeditiously deployed via airlift, ship, rail, roadway or multi-modal methods and have already proven their efficacy for more than a century. They have ably served in times of war, including the truck-based triage units deployed by Allied forces in North Africa in the Second World War. They provide first-response medical support in post-disaster humanitarian aid efforts, such as in the aftermath of the Haitian (2010) and Ecuadorian (2016) earthquakes. Traditionally, the vast majority of portable buildings for healthcare have emanated from military organisations, whereas a smaller percentage of privately financed portables for health are typically commissioned by non-governmental organisations (NGOs). Rapid response must be of utmost priority, to enable the expeditious transiting of the system/building and then its quick assembly on site. Generally, three types of mobile prefab systems for health applications exist: redeployable health centres (RHCs), redeployable trauma centres (RTCs) and permanent site modular installations (PMIs).

Five Variants: Transportables for Health

Within this typology, five variants are most promising at this time. The first of these – tent-based and pneumatic structures – are the most prevalent sort in use globally. Variations on the ancient tent and yurt have inspired most systems of this type in current use. Tents are lightweight, versatile, adaptable to diverse cultural and occupant needs, and responsive to topographically challenging terrain and many climatological contexts. Tent-based systems have evolved significantly in recent years, including the emergence of modular pneumatic systems. The majority of tent and pneumatic systems for health applications are commissioned by military organisations for deployment to combat theatres, such as the DEPMEDS (deployable medical units) used by the US Army in Iraq from Operation Desert Storm in 1991 until the end of the Iraq War in 2013. However, with the parallel dramatic increase in the occurrence of global disasters, these systems have taken on a more prominent role than ever before in humanitarian aid missions.

The second most prevalent type in current use is the vehicular nomadic unit. These RHCs and RTCs are prefabricated modules with additional interior componentry incorporated. Integral units (a single mobile entity) and two-element truck/trailer configurations predominate. The mobile field hospital proposed by a US architectural firm for the Moroccan Ministry of Health in 2010 consisted of a 48-bed inpatient hospital housed in numerous two-element modular units. Here, the MONARCH Corporation teamed with architects Hord Coplan Macht, of Baltimore, Maryland, to develop a full-scale nomadic, redeployable field hospital. This RHC/RTC inpatient installation is scalable up to 58 vehicular units, with some functioning as satellites transiting to and from nearby yet remote sites and then docking at the 'mothership' by night – without compromising intra-module connectivity.

Third, intermodal containerised systems have become the modular preferred choice for many healthcare organisations due to high structural strength and proven resilience in difficult transiting conditions across long distances. Containerised systems perform particularly well in this regard and can be close-packed during transit. They are typically custom-built, but some are based on adapted standardised shipping containers.[6] In the aftermath of the earthquake in Haiti, a US-based NGO, Care 2 Communities (C2C; formerly known as Containers 2 Clinics), commissioned three women's-health outpatient clinics. Generic containers provided the blank canvas for STANTEC/Stack Design's response. The installation consisted of three modules sited in close proximity to one another, creating an open-air courtyard at the centre. This space serves as the 'waiting room': a wooden deck with moveable chairs beneath a canvas roof that shields patients from the intense sun and frequent tropical downpours.

STANTEC/Stack Design,
C2C Women's Health Clinic,
Port-au-Prince,
Haiti,
2011

This unit was adapted from standard ISO (International Organization for Standardization) containers. Later units were custom-built to the client's detailed performance specifications.

Hord Coplan Macht with MONARCH Corporation, Mobile field hospital developed for the Moroccan Ministry of Health, 2010

Essentially a kit-of-parts, various combinations of modules are reconfigurable as needs change. Subsets of satellite units are able to un-dock and travel to local villages, returning to re-dock at night.

Fourth, flat-packs and pop-up systems consist of kit-of-parts assemblies shipped in standardised intermodal containers or specially designed containers. Upon arrival at the site of deployment, contents are removed and assembled. After this, the modules used strictly in transiting are storable on site or useable for ancillary functions, such as medications, clinical supplies, and equipment. Pop-ups are able to function as PMIs or RHCs, and can be effective rapid-response interventions in medically underserved communities in either routine everyday or post-disaster scenarios. Here, an existing structure functions as the host, with one or more pop-up modules installed within it. The possibilities for this type of intervention were recently explored in a research project within the Graduate Program in Architecture + Health at Clemson University in South Carolina (USA). Charleston, South Carolina and New Orleans, Louisiana were selected as the host cities. In these two communities, both situated in low-lying coastal regions, the adverse impacts of hurricanes and attendant tidal surge flooding are a constant threat. Both urban areas are predominately low-lying, with historical neighbourhoods containing many suitable host structures, heritage or otherwise, including neighbourhood churches, schools and their gymnasiums, and vacant commercial storefronts. Nineteen host structures were subsequently pre-tested for suitability via proposals to insert, in some hosts, an emergency triage unit, and in other hosts, a primary care clinic. It was learned that both cities would benefit from pop-up interventions in host structures because they could help empower residents to return confidently to their neighbourhood sooner than would probably be the case otherwise. This is because, in both cities, most (if not all) local brick-and-mortar hospitals would probably remain offline for weeks (if not months). In one proposed intervention in Charleston, a historical African-American congregational church is adapted into a host to a pop-up primary care RHC.

The fifth variant – hybrid portable systems – are composite and at times eclectic assemblies. This variant can consist of all three types (RHC/RTC/PMI) on a single site, synthesising the strongest attributes of intermodal containerised systems and tent- and mobile unit-based systems. When integrated, a tent or pneumatically activated membrane system, combined with modular containers, can afford a broad scope of aesthetic and functional performance possibilities. Their hybridity utilises offsite prefabrication construction methods with on-site manual construction assistance performed by local relief aid workers. Internal functions are distributed across 'hard' (container) and 'soft' (tent) portions of the total system. One example, the unbuilt SmartPOD (2013) proposal, developed at Clemson University in 2013, is a hybrid capable of operating remotely or tethered to a stationary medical centre. It is inspired by the aforementioned US portable infirmaries deployed in the Middle East. The undercarriage is a 12-metre-long (40-foot) custom-built module. Upon arrival, following container positioning, structural masts are erected followed by attachment of double-curvature tents stabilised by means of tension cables. The deployment illustrated is proposed for Washington, DC in the aftermath of a bioterrorist attack on the US Capitol.

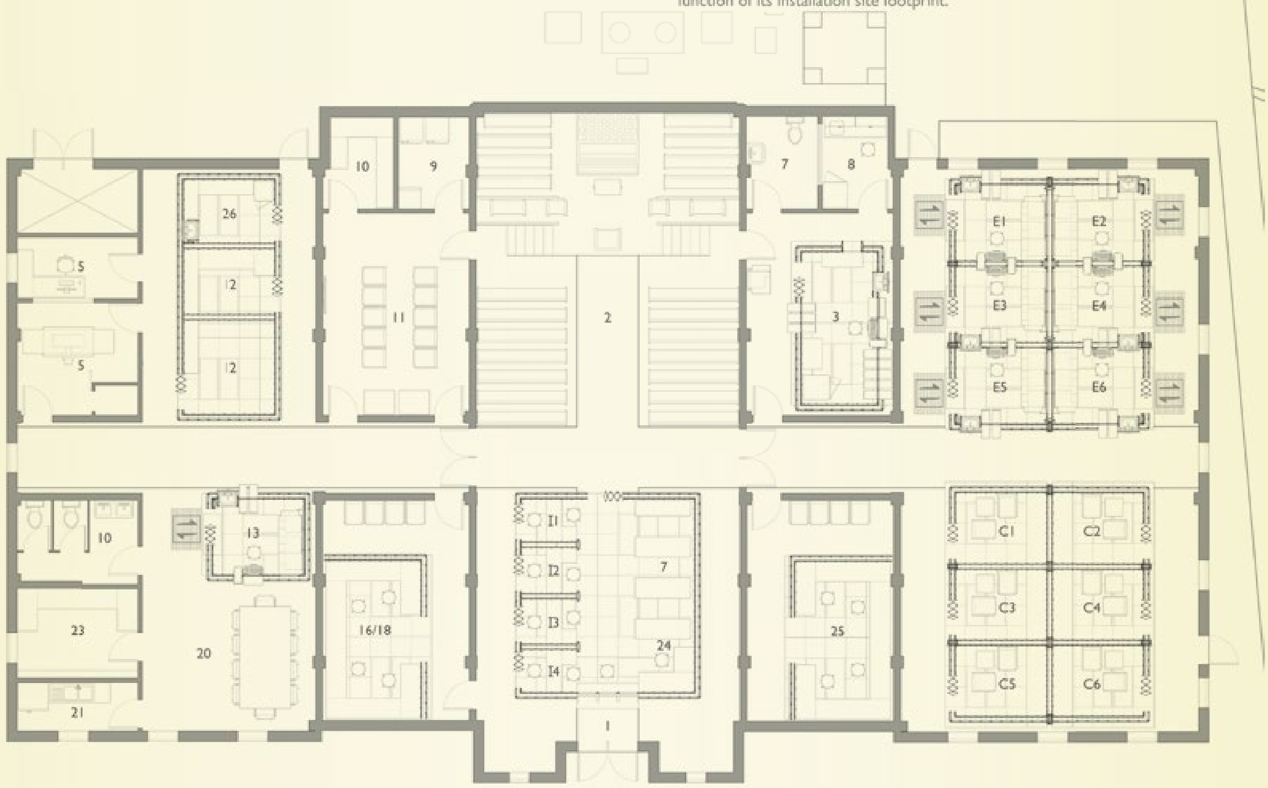
George Hughes with Stephen Verderber (Clemson University Graduate Program in Architecture + Health), Pop-up modular installation proposal for Church of Christ, Charleston, South Carolina, 2013

Plan and exterior view. This church has been a landmark in the African-American community in Charleston for over a century.

Key:

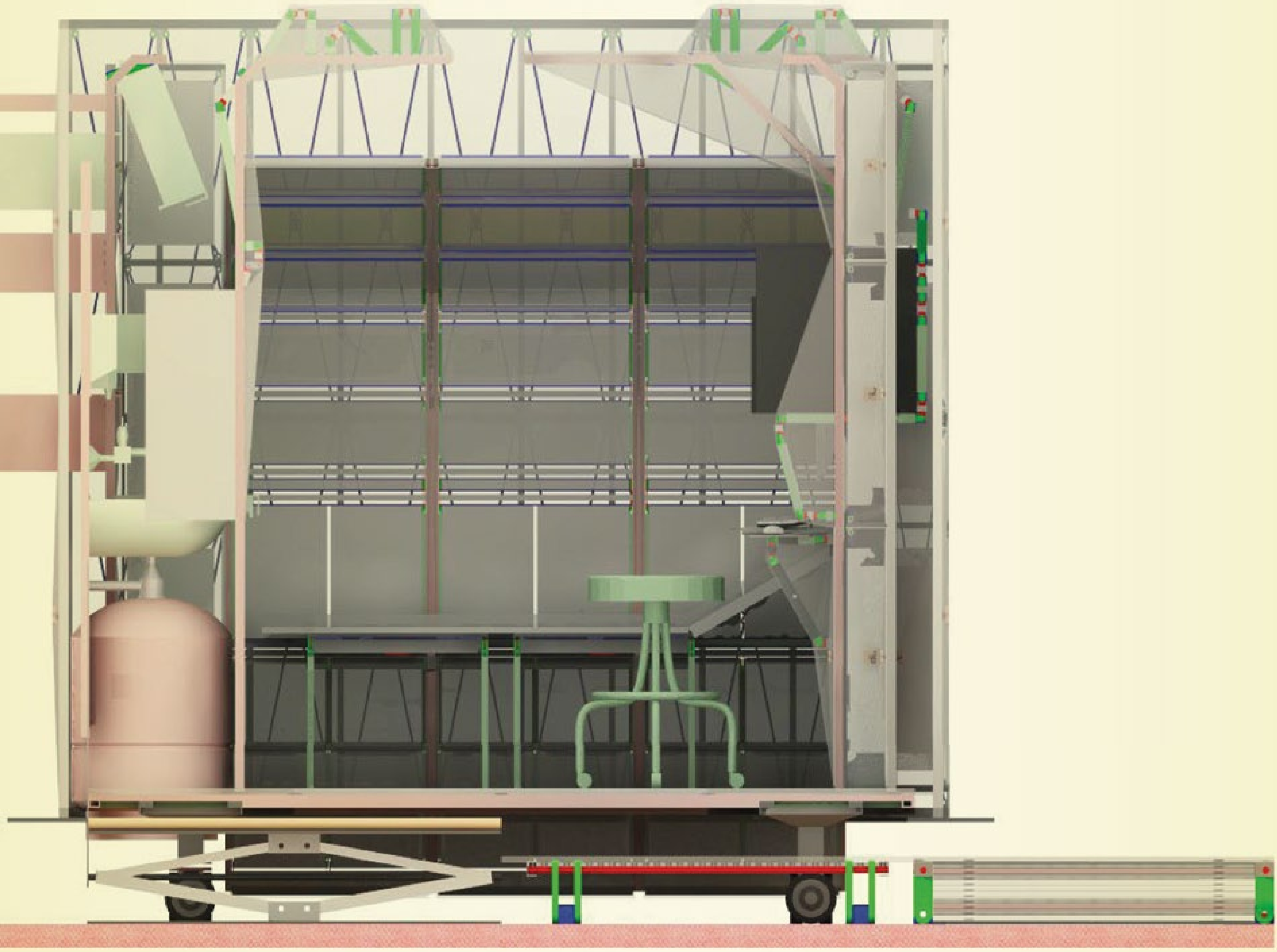
C1-C6	behavioral health consultation*
E1-E6	examination room*
I1-I4	patient intake*
1	patient sign-in
2	waiting area
3	laboratory
4	medications
5	office
6	clerical: work zone
7	medical records
8	staff restroom
9	men's restroom
10	women's restroom
11	patient restroom
12	environmental health
13	medications
14	subwaiting
15	nutrition
16	director
17	immunisations
18	physicians
19	biohazardous waste
20	health education/ conference
21	staff kitchen
22	housekeeping/janitor
23	storeroom
24	volunteers
25	nursing
26	TB/STD

* The number of rooms varies across the sites as a function of its installation site footprint.



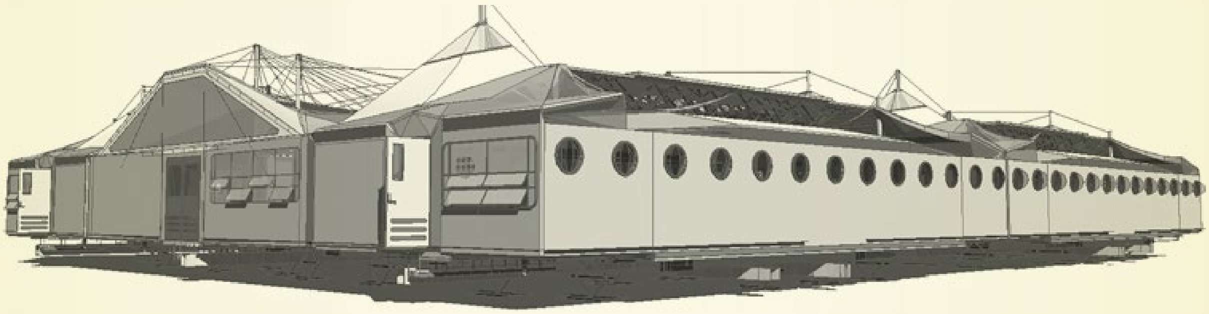
With regards to off-site prefabrication, inventive internal planning and manufacture of all modular parts is absolutely essential. It is often said, 'First and foremost, honour the matchline,' as this refers to the need for tight, precise connections and fittings between all componentry. Interior work and treatment zones need to optimalise the caregiver's ability to perform at the highest level. System-wide concerns include siting, aesthetics, internal ambiance, the installation's rapid identification, day or night, along with the provision of high-level air quality, natural daylight, artificial illumination, functional spatial adjacencies, ceiling configuration options, and provisions for furnishings and equipment. Some installations in current use, such as the field hospital owned by the Canadian Red Cross, arrive in a relatively self-sufficient state, complete with earth-moving devices, forklifts and modular power generation packages. As for siting concerns, football pitches, car parks, urban streets, parks and open fields are sought after. A system should be designed for autonomous operations or in tandem with a fixed-site hospital, as was the case with the BLU-MED portable facility deployed to Haiti in the aftermath of the 2010 earthquake. Flat-pack componentry typically can yield a more efficient use of containerisation space while en route, although the system then must be fully assembled on site. In systems based on variants of customised shipping containers, modules can be plugged together, resulting in a rigid, monolithic platform not unlike in the assembly of an automobile. Final assembly on site typically takes place by local workers under the guidance of trained personnel with (presumably) prior experience.

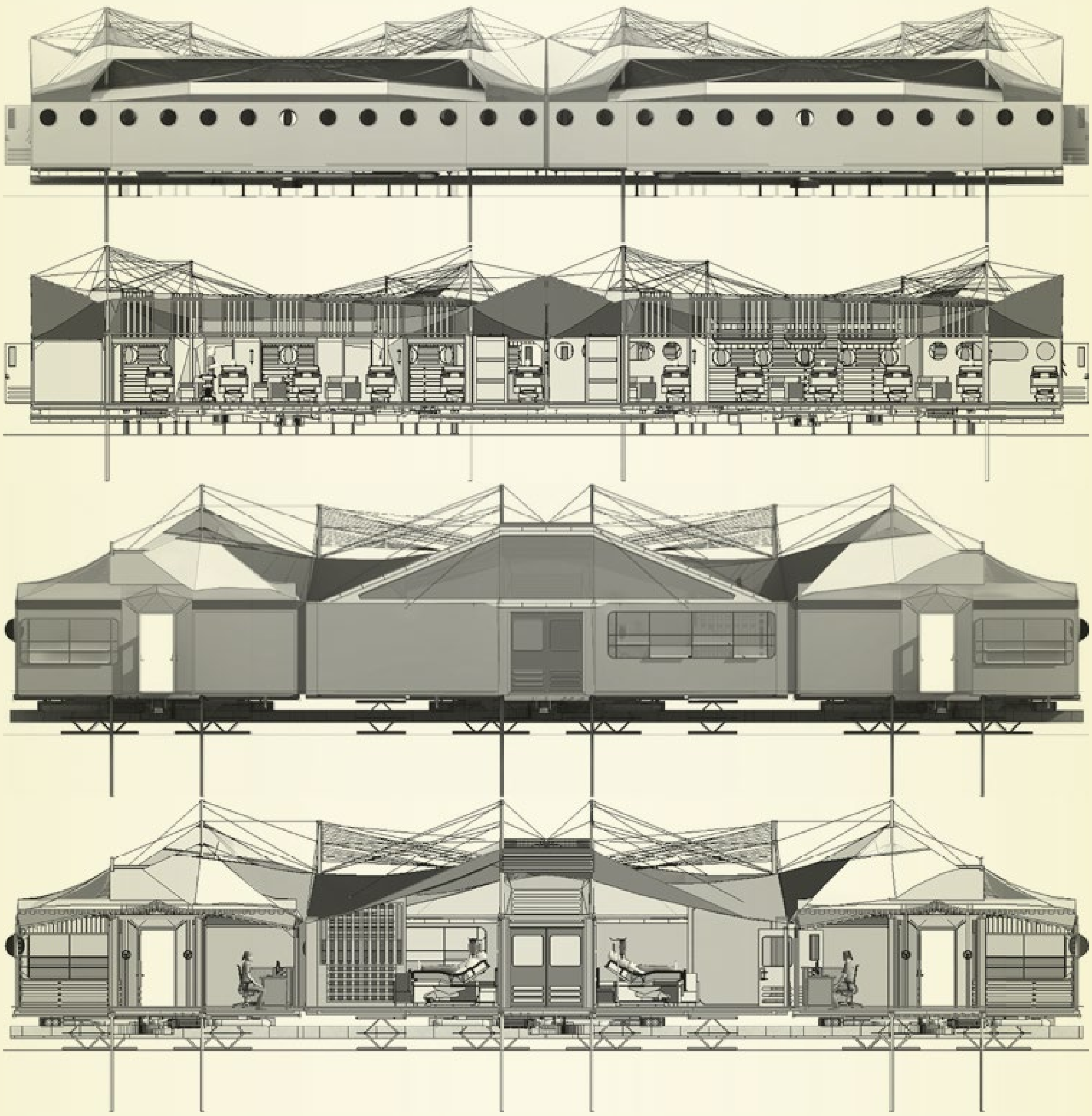
Section depicting the inner membrane of a typical module, with the outer structure aperture housing medical gases and related support infrastructure.



George Hughes with Stephen Verderber
(Clemson University Graduate Program in Architecture + Health),
SmartPOD portable hospital,
2013

Hybrid system comprised of containers, flat-pack panels and tents that provide substantial natural ventilation and daylight. This installation was proposed for deployment on Pennsylvania Avenue in Washington DC in the immediate aftermath of a bioterrorist attack.





Sustainable Healthcare Architecture and Portability

Is the underwhelming current reputation of the architect as a first responder wholly justified? Probably so. But before this can change for the better, a genuine attitude of public service, outreach, empathy and compassion for the plight of persons and places in need must exist. Off-site-built prefab precursors in housing and other building types warrant further research so that lessons can be learned and strengths, shortcomings and risk factors identified *a priori*. A working knowledge of sustainable off-site prefab processes must be carefully developed, including system tectonics, environmental support systems, transiting determinants, commissioning and decommissioning processes, daily functional performance and midstream retrofitting – while concurrently respecting the Vitruvian principles of architecture's provision of commodity, firmness and delight.[7] As for the sponsor/client, including NGOs, ministries of health, and policy specialists, it behooves all to embrace, far more than occurs now, the vast collaborative potential of architecture, engineering and industrial design to improve how things are done at present.

BLU-MED Response Systems with Alaska Structures, BLU-MED tent system, Haitian field deployment, 2010

Tent systems continue to be preferred by many first-response aid organisations for their lightness and ability to be erected locally by unskilled volunteers under the direction of trained personnel. The BLU-MED system is fabricated with lightweight aluminium frames for expeditious assembly.

Transportable architecture for health can contribute to a community's bounce-back resiliency, its future sustainability, and therefore its reconstituted, collective social capital. Albeit, shattered social networks are very challenging to reconstitute. The presence of a portable prefab clinic can symbolise that it is safe, it is OK to return. This alone greatly aids in fostering reaffirmative place-reattachment behaviours, behaviours prerequisite to effective community rebuilding. A portable structure for health simultaneously fosters ecological sustainability for the way it is built, alone, versus, by comparison, carbon-neutral advancements in fixed-site architecture for health that are often slow to be adopted, with sustainability innovations occurring, randomly, in a series of fits and starts. The examples discussed above seek to attain the most efficient use of construction materials and to recycle material waste. Energy consumption is measurable, including mechanical, electrical, plumbing systems and daily maintenance expenses – with the aim of infusing clean energy sources (solar, wind) and maximising geographic and climatological functional range as well as an installation's ecological lightness. Beyond this, as inferred above, a portable, nomadic healthcare facility can foster health-promotion and community rebuilding by simply arriving at the pre- or post-disaster site in a timely manner. The ability to administer first-response triage, the testing of water samples, immunisations and chemical agent decontamination in addition to minor surgical procedures, is of indispensible value to caregivers and victims alike.

For the discipline of architecture, and particularly for the architectural historian, it continues to remain a challenge to properly place portable buildings within broader theory-based discursive streams of inquiry and analysis. Despite this ever-present conundrum, progressive experimentation continues to be absolutely essential if architects and allied designers are to achieve measurable success in meeting the global need for first-response, sustainable architecture of this type. ᗝ

Notes

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7. Stephen Verderber, *Innovations in Transportable Healthcare Architecture*, Routledge (London), 2016.